Soil Quality

Soil Quality is the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries to:

- Sustain plant and animal productivity.
- Maintain or enhance water and air quality.
- Support human health and habitation.

Soil function describes what the soil does. Healthy soil gives us clean air and water, bountiful crops and forests, productive rangeland, diverse wildlife, and beautiful landscapes. There are five essential functions:

1. **Regulating water.** Soil helps control where rain and irrigation water goes. Water and dissolved solutes flow over the land or into and through the soil.
2. **Sustaining plant and animal life.** The diversity and productivity of biological activity depends on the soil.
3. **Filtering potential pollutants.** The minerals and microbes in soil are responsible for filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric deposits.
4. **Cycling and storing nutrients.** Carbon, nitrogen, phosphorus, and may other nutrients are stored, transformed, and cycled through the soil.
5. **Supporting structures.** Buildings need stable soil for support, and archeological treasures associated with human habitation are protected in soils.

Soils vary naturally in their capacity to function; therefore, **quality is specific to each kind of soil**. This concept encompasses two distinct but interconnected parts: Inherent quality and Dynamic quality. Characteristics, such as texture, mineralogy, etc., are soil properties determined by the factors of soil formation – climate, topography, vegetation, parent material, and time. These properties determine the **inherent quality** of a soil. They help compare one soil to another and evaluate soils for specific uses. For example, sandy soil drains faster than clayey soil. Deep soil has more room for roots than soils with bedrock near the surface. These characteristics do not change easily. **Dynamic quality** is how a soil changes depending on how it is managed. Management choices affect the amount of soil organic matter, soil structure, soil depth, water and nutrient holding capacity. In soil quality research one goal is to learn how to manage soil in a way that improves soil function. Soils respond differently to management depending on the inherent properties of the soil and the surrounding landscape. Some management practices, such as the use of cover crops can increase organic matter and have a positive effect on soil quality. Other management practices, such as tilling the soil when wet, adversely affect soil quality by increasing compaction.

Soil quality is an assessment of how well soil performs all of its functions. It cannot be determined by measuring only crop yield, water quality, or any other single outcome. The quality of a soil is an assessment of how it performs all of its functions at the present time and how those functions are being preserved for future use. Soil quality cannot be measured directly, so we evaluate indicators. Indicators are measurable properties of soil or plants that provide clues about how well the soil can function. Indicators can be physical, chemical, and biological characteristics. Useful indicators:

- Are easy to measure
- Measure changes in soil functions
- Encompass chemical, biological, and physical properties
- Are accessible to many users and applicable to field conditions
- Are sensitive to variations in climate and management.
- Can be assessed by qualitative and/or quantitative methods.

Here are some examples of indicators of soil quality:

Indicator	**Relationship to Soil Health**
Soil Organic Matter (SOM)	Soil fertility, structure, stability, nutrient retention; soil erosion.
<u>PHYSICAL:</u> Soil structure, Depth of soil, Infiltration and bulk density; Water holding capacity.	Retention and transport of water and nutrients; habitat for microbes; estimate of crop productivity potential; compaction, plow pan, water movement; porosity; workability.
<u>CHEMICAL:</u> pH; Electrical conductivity; extractable N-P-K.	Biological and chemical activity thresholds; Plant and microbial activity thresholds; Plant available nutrients and potential for N and P loss.
<u>BIOLOGICAL:</u> Microbial biomass C and N; Potentially mineralizable N; Soil respiration.	Microbial catalytic potential and repository for C and N; Soil productivity and N supplying potential; Microbial activity measure.

The methods that are qualitative and/or quantitative that are used to assess soil quality are:

- Soil Health Card
- NRCS Soil Health Card Template (NRCS Template)
- Soil Quality Test Kit
- Laboratory analysis

The soil health, or soil quality, assessment card is a qualitative tool designed by and for farmers. The cards contain farmer-selected soil quality indicators and associated ranking descriptions typical of local producers. Generally, indicators listed, such as soil tilth, abundance of earthworms, or water infiltration, can be assessed without the aid of technical or laboratory equipment.

The NRCS Soil Health Card Template is a qualitative soil quality assessment used for an NRCS conservation plan. The card can be adapted for local use by using the NRCS Template. When adapting the template, select only locally relevant indicators and descriptive terms, and be sure to add others that are needed for local soil and agricultural systems. Generally, no more than 10 indicators should be used on a template, as too many questions make the process cumbersome. The Soil Quality Test Kit, developed by the ARS, is an on-farm soil quality assessment tool. It was modified and enhanced by the NRCS Soil Quality Institute with NRCS field staff. The kit is used as a screening tool to give a general direction or trend of soil quality; (e.g., whether current management systems are maintaining, enhancing, or degrading the soils). It can also be used to troubleshoot problem areas in the field. Included in the kit are tools to measure standard soil quality indicators such as respiration, water infiltration, bulk density, electrical conductivity, pH, aggregate stability, slaking, and earthworms. Laboratory analyses conducted by soil testing laboratories throughout the U.S. have tests for many soil properties that are useful for soil quality evaluation. While some of these tests can also be done with the Soil Quality Test Kit, farmers may not have the time to run the tests, or they may prefer to obtain their results from an accredited laboratory.

The ultimate purpose of researching and assessing soil quality is not to achieve high aggregate stability, biological activity, or some other soil property. The purpose is to protect and improve long-term agricultural productivity, water quality, and habitats of all organisms including people. We use soil characteristics as indicators of soil quality, but in the end, soil quality must be identified by how it performs its functions. Each combination of soil type and land use calls for a different set of practices to enhance soil quality. Several principles apply in most situations:

1. <u>Add organic matter</u>. Regular additions of organic matter are linked to many aspects of soil quality. Organic matter may come from crop residues at the surface, roots of cover crops, animal manure, green manure, compost, and other sources. Organic matter, and the organisms that eat it, can improve water holding capacity, nutrient availability, and can help protect against erosion.

2. <u>Avoid excessive tillage</u>. Tillage has positive effects, but it also triggers excessive organic matter degradation, disrupts soil structure, and can cause compaction.

3. Carefully manage fertilizer and pesticide use. In the last century, pesticides and chemical fertilizers have revolutionized U.S. agriculture. In addition to their desired effects, they can harm non-target organisms and pollute water and air if they are mismanaged. Manure and other organic matter also can become pollutants when misapplied or over-applied. On the positive side, fertilizer can increase plant growth and the amount of organic matter returned to the soil.

4. Increase ground cover. Bare soil is susceptible to wind and water erosion, and to drying and crusting. Ground cover protects soil, provides habitats for larger soil organisms, such as insects and earthworms, and can improve water availability. Cover crops, perennials, and surface residue increase the amount of time that the soil surface is covered each year.

5. Increase plant diversity. Diversity is beneficial for several reasons. Each crop contributes a unique root structure and type of residue to the soil. A diversity of soil organisms can help control pest populations, and a diversity of cultural practices can reduce weed and disease pressures. Diversity across the landscape and over time can be increased by using buffer strips, small fields, strip cropping, crop rotations, and by varying tillage practices. Changing vegetation across the landscape or over time increases plant diversity, and the types of insects, microorganisms, and wildlife.

For further guidance on Soil Quality see Sections 190-22-11 through 190-22-15 in the Soil Quality Thunderbook.